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WEIGHT-VOLUME RELATIONSHIPS OF ASPEN AND WINTER-CUT BLACK SPRUCE PULPWOOD IN NORTHERN MINNESOTA

David C. Lothner, *Associate Market Analyst*
Richard M. Marden, *Principal Forest Products Technologist*
Edwin Kallio, *Principal Market Analyst*
Duluth, Minnesota
(Office maintained in cooperation with the University of Minnesota-Duluth)

ABSTRACT.-- Seasonal weight-volume relationships were determined for rough (bark on) aspen and black spruce 100-inch pulpwood that was delivered within 1 week after cutting in northern Minnesota during 1971-72. For aspen, the weight of wood and bark per cubic foot of wood averaged 56 pounds in the winter and 61 pounds in the summer. This relationship for winter-cut black spruce was approximately 53 pounds.

OXFORD:526.1:527:174.7 *Picea mariana* (776).
KEY WORDS: weight scaling, *Populus tremuloides*, *Picea mariana*.

APPLICATION

Those involved in the Minnesota pulpwood market are confronted with a need for information on weight-volume relationships of pulpwood species in northern Minnesota because weight scaling is fast becoming recognized as a more efficient measuring technique. Only a few Minnesota firms purchase pulpwood by weight at present, but we can expect an ever-increasing amount of wood to be weight scaled in the future. All governmental agencies in Minnesota now have the authority to sell timber stumpage by weight where consumers have the facilities for weighing, and many pulpwood producers are taking advantage of this opportunity. In addition, an increasing amount of pulpwood in northern Minnesota is being purchased in tree-length form, which makes it impractical to use conventional volume measurements.

For aspen (*Populus tremuloides* Michx.), we developed monthly and seasonal conversion factors for summer (June-October) and for winter (November-March) of pounds of wood and bark per cubic foot of wood (table 1). These factors are for rough 100-inch wood (bark on) delivered to the mill within 1 week after cutting. Although we did not cord scale the loads, we converted the seasonal conversion factors into pounds per Unit[1] for a range of cubic feet of wood per unit.

Only a seasonal factor for winter (November-March) is given for black spruce (*Picea mariana* (Mill.)B.S.P.) because most of the black spruce cut for pulpwood in Minnesota grows in swamps that are best logged only after freeze-up. However, some loggers do cut black spruce pulpwood during the summer but are unable to transport it until the swamps freeze. Pulpwood that has been cut for more than a month before delivery is usually stick scaled or purchased on the basis of a special "seasoned" weight.

As illustrated in figure 1, spring breakup (April and May) and September and

[1] *A Unit = 4 ft (4 ft) 8.33 ft = 133.3 ft^3 which is an expression of stacked volume commonly used in Minnesota.*

Table 1.--*Weight of wood and bark per cubic foot of aspen pulpwood by month and season*[1]

Month	Loads	Wood and bark per cu. ft. of wood	
		Average	Range[2]
	No.	*Lbs.*	*Lbs.*
SUMMER			
June	21	56.30	54.20-58.40
July	16	55.22	51.99-58.45
Aug.	17	55.71	54.01-57.42
Sept.	17	55.89	54.27-57.50
Oct.	13	57.34	55.05-59.63
Ave.	84	56.09	55.12-57.06
WINTER			
Nov.	9	62.15	60.21-64.10
Dec.	17	61.27	58.70-63.83
Jan.	25	61.78	60.21-63.35
Feb.	18	59.78	58.14-61.42
March	20	58.72	56.51-60.93
Ave.	89	60.74	59.86-61.61

[1]*All pulpwood was cut during the period January 1971-March 1972, except during the spring breakup months of April and May, within a 70-mile radius semicircle south of International Falls, Minn., and delivered within 1 week after cutting.*

[2]*Calculated at a 95 percent confidence interval, which indicates that authors can be 95 percent certain that these ranges include the true means.*

October are the transition periods in which the rate of change in weight per volume is greatest. This was the basis for grouping months to obtain the summer and winter conversion factors.

For aspen, the winter conversion factor was 60.74 pounds of wood and bark per cubic foot of wood. The summer conversion factor was 56.09 pounds of wood and bark per cubic foot of wood.

For black spruce, the winter conversion factor was 52.78 pounds of wood and bark per cubic foot of wood.

In deriving these seasonal conversion factors, we assumed that an equal volume of pulpwood is delivered each month of the season. However, a different prorating scheme could be used to develop seasonal conversion factors from the monthly averages if a user's deliveries are considerably greater during certain months than during others.

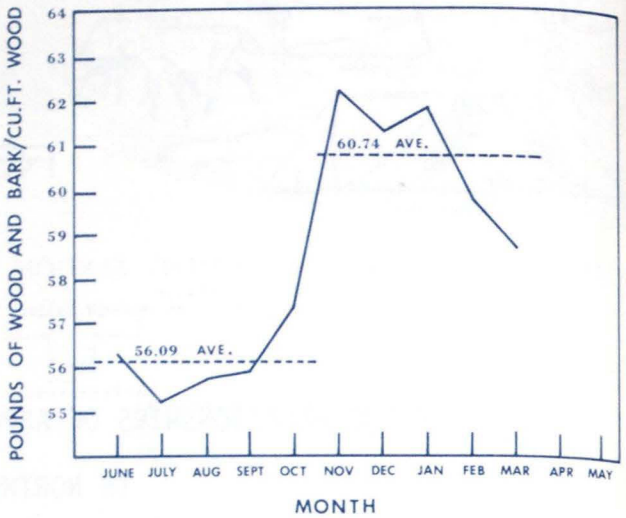

Figure 1.--*Mean value of pounds of wood and bark per cubic foot of wood for 100-inch aspen pulpwood delivered within 1 week after cutting.*

We recognized that stick-scaled estimates are affected by judgment and procedure differences among scalers, buyers, and government agencies as well as by differences in stick straightness, piling techniques, and distribution of stick diameters. Past experience has shown that a volume of a unit of aspen pulpwood can range from 74 to 84 cubic feet and that a unit of black spruce pulpwood can range from 78 to 88 cubic feet. Because of these differences, we developed conversion factors in pounds per unit for the range of volumes shown in table 2. Users can select the factor that best fits their operations or compromise on an alternative.

DOCUMENTATION

Weight scaling of pulpwood (and occasionally of saw logs and other timber products) has gained acceptance in many areas of the United States and Europe. Some advantages of weight scaling have been reported: good wood quality is encouraged (Barienbrock 1959); system is more equitabetween buyer and seller (Eggen 1967); helps solve bookkeeping problems (Chamberlain 1958); reduces total scaling time and improves accuracy (Muller 1958); pulpwood inventories are more easily maintained (Taras 1956); and promotes safety in scaling (Guttenberg 1967).

Table 2.--*Seasonal weights per Unit for alternative number of cubic feet of aspen and black spruce pulpwood*[1]

Season[2]	Volume of wood/unit	Wood and bark per unit	
		Average	Range[3]
	Cu. Ft.	*Lbs.*	*Lbs.*
ASPEN			
Summer	76	4,263	4,189-4,337
Winter		4,616	4,549-4,682
Summer	78	4,375	4,299-4,451
Winter		4,738	4,669-4,806
Summer	80	4,487	4,410-4,565
Winter		4,859	4,789-4,929
Summer	82	4,599	4,520-4,679
Winter		4,981	4,909-5,052
Summer	84	4,712	4,630-4,793
Winter		5,102	5,028-5,175
BLACK SPRUCE			
Winter	78	4,117	4,044-4,190
	80	4,222	4,148-4,298
	82	4,328	4,252-4,405
	84	4,434	4,355-5,512
	86	4,539	4,459-4,620
	88	4,645	4,563-4,727

[1]*All pulpwood was cut during the period January 1971-March 1972, except during the spring breakup months of April and May, within a 70-mile radius semicircle south of International Falls, Minn., and delivered within 1 week after cutting.*

[2]*Summer: June-October. Winter: For aspen, November-March; for black spruce, January-March.*

[3]*Calculated at a 95 percent confidence interval, which indicates that authors can be 95 percent certain that these ranges include the true means.*

However, Hall and Rudolph (1957) did indicate that weight scaling works to the disadvantage of sellers who delay selling jack pine pulpwood after it is cut. This, of course, is attributed to the loss of moisture from the wood that occurs soon after timber is felled. Moisture content of standing trees can also vary by seasons and geographic locations, as well as climatic conditions and soils.

Study Methods

We weighed and measured[2] 173 truckloads of aspen pulpwood and 47 truckloads of black spruce pulpwood from January 1971 through March 1972. Aspen was sampled each month except during spring breakup (April and May). Only the black spruce sample loads delivered during January through March both in 1971 and 1972 were used in the analysis because there was not a sufficient number of loads delivered during the other months to ensure a statistically reliable sample.

From a presample taken in 1970, we had determined that approximately 16 loads a month should be measured to allow for no more than a 2 percent error in the average seasonal weights of wood and bark per cubic foot of wood at the 95 percent confidence level. Sampling was spread through each month as much as practicable.

Load weights were obtained by weighing the loaded truck and unloaded truck on a 50-ton platform scale at the Boise-Cascade woodyard in International Falls, Minn. After the initial weighing (loaded), the truck was positioned for photographing.

Three sticks were randomly selected and removed from the top of each load after it was photographed. The sticks were identified (load and stick number) and their lengths were measured to 1/10 foot to provide a check on adherence to the 100-inch length specification. A disk (1 inch thick) was cut from the middle of each stick on which measurements were taken--outside bark (d.o.b.) and inside bark (d.i.b.)--and averaged (to 1/10 inch) to use in calculating the proportion of volume in wood and in bark. These disks were cut into half sections from which the bark was peeled so that the wood and bark could be weighed separately (to 1/10 gram). The wood and bark from each section were then bagged together for later use in determining seasonal variations in moisture content.

Photographic slides of each section of the pulpwood loads were projected on a rear-projection screen.[2] We measured the pulpwood sticks on the projected image and applied the following volume formula:

$$V = \frac{\left(\frac{D}{2}\right)^2 \pi \ 100}{144(12)} = 0.04545 \ D^2$$

where V = volume in cubic feet, and D = diameter outside bark to the nearest 1/10 inch.

All aspen sticks 12 inches or greater d.o.b. were measured but only every fifth aspen stick among those less than 12 inches

[2]*Details of procedure are described in Kallio* et al. *(1973).*

d.o.b. were measured.[3] By measuring only one out of five of the smaller d.o.b. sticks, we obtained a higher degree of statistical accuracy than we would have obtained by measuring all of these sticks because of the larger number of aspen loads. However, we had to measure all of the sticks in the smaller number of black spruce loads to avoid the additional variation associated with subsampling.

Monthly ratio estimates[4] were used for estimating pounds of wood and bark per cubic foot of wood and bark. (See Chap. 6, Cochran 1963.)

The d.o.b. and d.i.b. measurements from the disks were used to calculate the wood proportion to total (wood plus bark) cubic foot volume as follows:

$$\text{Proportion wood} = \frac{\sum_{i=1}^{n} \text{d.i.b.}^2}{\sum_{i=1}^{n} \text{d.o.b.}^2}.$$

The average wood proportion (all truckloads combined) was applied to obtain the conversion factor as follows:

$$\frac{\text{Pounds of } \textit{wood} \text{ and } \textit{bark} \text{ per cubic foot of } \underline{\textit{wood}} \text{ and } \underline{\textit{bark}}}{\text{Proportion wood}} = \text{Pounds of } \textit{wood} \text{ and } \textit{bark} \text{ per cubic foot of } \textit{wood}.$$

The average wood proportion obtained from disk measurements from all of the aspen loads was 88.2 percent. This figure was used in the 1971-72 data analysis to develop monthly and two seasonal conversion factors of pounds of wood and bark per cubic foot of wood (table 1).

For black spruce, the average proportion of wood by volume obtained from the disk measurements was 92.8 percent. This figure was used to develop the winter conversion factor.

[3] *The first stick measured was chosen randomly among the first five sticks with a d.o.b. less than 12 inches.*

[4] $\textit{Ratio estimate} = \dfrac{\sum_{i=1}^{n} \textit{load weights}}{\sum_{i=1}^{n} \textit{load volumes}}.$

Discussion

Our research results show a significant difference in weight per unit volume between summer and winter months for aspen pulpwood delivered to the woodyard within 1 week after cutting. Because our black spruce data were confined to the January through March period, a comparison between a summer and winter season was not possible. However, our conversion factors for both species represent a given period of time and one location (an approximate 70-mile semicircle around International Falls). Weather conditions do vary from year to year. In addition, we have no evidence that our seasonal weight-volume factors would not vary from one location to another. Therefore, checks should be made on year-to-year variations as well as location differences.

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